In re Patent Application of:

BHARDWA ET AL
Serial No. **09/977,065**
Filed: **OCTOBER 12, 2001**

Amendments to the Claims

1. (Currently amended) A planar lightwave circuit comprising:

a) a substrate;

b) at least one optical waveguide core;

c) an undercladding formed over the substrate and under the core;

d) at least one feature proximate the core having at least one stress-engineered property to balance stress and therefore minimize birefringence affecting the core, wherein the one feature comprises an overcladding layer formed over the core, and doped to balance stress affecting the core wherein the overcladding is doped to have a coefficient of thermal expansion approximately matched to that of the substrate to thereby symmetrically distribute stress in the undercladding between the overcladding and the substrate, and therefore away from the core; and

e) a protective passivation layer ~~formed over the core and the feature, the passivation layer formed to be substantially non-interfering with the balanced stress affecting the core provided by the feature~~ comprising silicon nitride formed over the core and the feature, the passivation layer have a coefficient of thermal expansion approximately matched to that of the overcladding such that it is substantially non-interfering with the balanced stress affecting the core provided by the overcladding.

2. (currently amended) The planar lightwave circuit of claim 1, wherein the ~~at least one feature comprises an overcladding layer formed over the core, and doped to balance stress affecting the core~~ overcladding and the passivation layer have

a matched CTE and together provide the balanced stress to counter stress within the core, thereby minimizing the overall birefringence.

Claims 3 to 5 (Cancelled)

6. (currently amended) The planar lightwave circuit of claim [[4]] 1, wherein the at least one feature comprises portions of the undercladding, respectively adjacent to each lower edge of the core, terminating at a point lower than the core, to further effect a removal of stress away from the core.

7. (currently amended) The planar lightwave circuit of claim [[4]] 1, wherein the at least one feature comprises a stress release groove formed through the overcladding between two cores of the at least one core, the stress release groove releasing and therefore balancing stress affecting the two cores.

8. (currently amended) ~~The~~ A planar lightwave circuit ~~of claim 7, wherein a second overcladding is formed along walls and a floor of the stress release groove to partially but not completely fill the groove to preserve its stress releasing property, but sufficient to support a generally planar portion of the passivation layer over the groove~~, comprising:
a substrate; and
an undercladding formed over the substrate and under the core;
at least one optical waveguide core;
at least one feature proximate the core having at least one stress-engineered property to balance stress and therefore minimize birefringence affecting the core, wherein the at

least one feature comprises an overcladding layer formed over the core, and doped to balance stress affecting the core wherein the overcladding is doped to have a coefficient of thermal expansion approximately matched to that of the substrate to thereby symmetrically distribute stress in the undercladding between the overcladding and the substrate, and therefore away from the core, wherein the at least one feature comprises portions of the undercladding, respectively adjacent to each lower edge of the core, terminating at a point lower than the core, to further effect a removal of stress away from the core, wherein the at least one feature comprises a stress release groove formed through the overcladding between two cores of the at least one core, the stress release groove releasing and therefore balancing stress affecting the two cores; wherein a second overcladding is formed along walls and a floor of the stress release groove to partially but not completely fill the groove to preserve its stress releasing property, but sufficient to support a generally planar portion of the passivation layer over the groove; and,

a protective passivation layer formed over the core and the feature, the passivation layer formed to be substantially non-interfering with the balanced stress affecting the core provided by the feature, wherein the protective passivation layer comprises silicon nitride and is formed to have a coefficient of thermal expansion approximately matched to that of the overcladding such that it is substantially non-interfering with the balanced stress affecting the core provided by the overcladding.

9. (original) The planar lightwave circuit of claim 7, wherein the at least one feature comprises portions of the undercladding, respectively adjacent to opposing lower edges

of each core, terminating at a point lower than the cores, to further effect a removal of stress away from the cores.

10. (original) The planar lightwave circuit of claim 9, wherein the lower point corresponds with the bottom of the stress release groove to thereby provide an identifiable etch transition point for the stress release groove.

11. (previously amended) The planar lightwave circuit of claim 1, wherein the at least one feature comprises a stress release groove formed through the overcladding between two cores of the at least one core, the stress release groove releasing and therefore balancing stress affecting the two cores.

12. (currently amended) ~~The~~ A planar lightwave circuit ~~of claim 11,~~ , comprising:

at least one optical waveguide core;

at least one feature proximate the core having at least one stress-engineered property to balance stress and therefore minimize birefringence affecting the core, said one feature comprising a stress release groove formed through overcladding between two cores of the at least one core, the stress release groove releasing and therefore balancing stress affecting the two cores,

; and

a protective passivation layer formed over the core and the feature, the passivation layer formed to be substantially non-interfering with the balanced stress affecting the core provided by the feature, wherein a second overcladding is formed along walls and floor of the stress release groove to partially but not completely fill the groove to preserve its

stress releasing property, but sufficient to support a generally planar portion of the passivation layer over the groove.

13. (original) The planar lightwave circuit of claim 1, wherein the at least one feature comprises portions of an undercladding, respectively adjacent to each lower edge of the core, terminating at a point lower than the core, to further effect a removal of stress away from the core.

14. (currently amended) A method for forming a planar lightwave circuit, comprising:
forming at least one optical waveguide core;
<u>providing a substrate and an undercladding formed over the substrate, over which the core is formed;</u>
forming at least one feature proximate the core having at least one stress-engineered property to balance stress and therefore minimize birefringence affecting the core<u>, wherein the step of forming the at least one feature comprises the steps of forming an overcladding layer over the core; and doping the overcladding to balance stress affecting the core, wherein the overcladding is doped to have a coefficient of thermal expansion approximately matched to that of the substrate to thereby symmetrically distribute stress in the undercladding between the overcladding and the substrate, and therefore away from the core</u>; and
forming a protective passivation layer over the core and the feature, the passivation layer formed to be substantially non-interfering with the balanced stress affecting the core provided by the feature<u>, said forming the protective passivation layer comprising the step of forming the layer to</u>

have a coefficient of thermal expansion approximately matched to that of the overcladding such that it is substantially non-interfering with the balanced stress affecting the core provided by the overcladding.

15. (previously amended) The method of claim 14, wherein said forming the at least one feature comprises:

forming an overcladding layer over the core; and

doping the overcladding to balance stress affecting the core.

16. (original) The method of claim 15, further comprising:

providing a substrate and an undercladding formed over the substrate, over which the core is formed;

wherein the overcladding is doped to have a coefficient of thermal expansion approximately matched to that of the substrate to thereby symmetrically distribute stress in the undercladding between the overcladding and the substrate, and therefore away from the core.

17. (original) The method of claim 16, wherein said forming the protective passivation layer comprises:

forming the layer to have a coefficient of thermal expansion approximately matched to that of the overcladding such that it is substantially non-interfering with the balanced stress affecting the core provided by the overcladding.

18. (original) The method of claim 17, wherein the passivation layer comprises silicon nitride.

19. (original) The method of claim 17, wherein said forming the at least one feature comprises:

removing portions of the undercladding, respectively adjacent to each lower edge of the core, to a point lower than the core, to further effect a removal of stress away from the core.

20. (original) The method of claim 17, wherein said forming the at least one feature comprises:

forming a stress release groove through the overcladding between two cores of the at least one core, the stress release groove releasing and therefore balancing stress affecting the two cores.

21. (currently amended) ~~The~~ A method ~~of claim 20, further~~ for forming a planar lightwave circuit, comprising:

a) forming at least one optical waveguide core;

b) forming an overcladding layer over the core;

c) providing a substrate and an undercladding formed over the substrate, over which the core is formed;

d) forming at least one feature proximate the core having at least one stress-engineered property to balance stress and therefore minimize birefringence affecting the core, wherein said forming the at least one feature comprises:

doping the overcladdding to balance stress affecting the core, wherein the overcladding is doped to have a coefficient of thermal expansion approximately matched to that of the substrate to thereby symmetrically distribute stress in the undercladding between the overcladding and the substrate, and therefore away from the core; said forming the at least one feature further comprising:

removing portions of the undercladding, respectively adjacent to each lower edge of the core, to a point lower than the core, to further effect a removal of stress away from the core, wherein said forming the at least one feature further comprises: forming a stress release groove through the overcladding between two cores of the at least one core, the stress release groove releasing and therefore balancing stress affecting the two cores;

e) forming a protective passivation layer over the core and the feature, the passivation layer formed to be substantially non-interfering with the balanced stress affecting the core provided by the feature, the passivation layer comprising silicon nitride formed to a coefficient of thermal expansion approximately matched to that of the overcladding such that it is substantially non-interfering with the balanced stress affecting the core provided by the overcladding; and

f) forming a second overcladding along walls and floor of the stress release groove to partially but not completely fill the groove to preserve its stress releasing property, but sufficient to support a generally planar portion of the passivation layer over the groove.

22. (original) The method of claim 20, wherein said forming the at least one feature comprises:

removing portions of the undercladding, respectively adjacent to opposing lower edges of each core, to a point lower than the cores, to further effect a removal of stress away from the cores.

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23. (original) The method of claim 22, wherein the lower point corresponds with the desired bottom of the stress release groove, the method further comprising:

using the lower point as an identifiable etch transition point for the stress release groove while forming the stress release groove.

24. (original) The method of claim 14, wherein said forming the at least one feature comprises:
forming a stress release groove through overcladding between two cores of the at least one core, the stress release groove releasing and therefore balancing stress affecting the two cores.

25. (currently amended) ~~The~~ A method ~~of claim 24, further~~ for forming a planar lightwave circuit, comprising:
forming at least one optical waveguide core;
providing a substrate and an undercladding formed over the substrate, over which the core is formed;
forming at least one feature proximate the core having at least one stress-engineered property to balance stress and therefore minimize birefringence affecting the core, wherein the step of forming the at least one feature comprises the steps of forming an overcladding layer over the core; and doping the overcladding to balance stress affecting the core, wherein the overcladding is doped to have a coefficient of thermal expansion approximately matched to that of the substrate to thereby symmetrically distribute stress in the undercladding between the overcladding and the substrate, and therefore away from the core, wherein said forming the at least one feature comprises:

<u>forming a stress release groove through overcladding between two cores of the at least one core, the stress release groove releasing and therefore balancing stress affecting the two cores;</u>

<u>forming a protective passivation layer over the core and the feature, the passivation layer formed to be substantially non-interfering with the balanced stress affecting the core provided by the feature, said forming the protective passivation layer comprising the step of forming the layer to have a coefficient of thermal expansion approximately matched to that of the overcladding such that it is substantially non-interfering with the balanced stress affecting the core provided by the overcladding; and,</u>

forming a second overcladding along walls and floor of the stress release groove to partially but not completely fill the groove to preserve its stress releasing property, but sufficient to support a generally planar portion of the passivation layer over the groove.

26. (original) The method of claim 14, wherein said forming the at least one feature comprises:

removing portions of an undercladding, respectively adjacent to each lower edge of the core, to a point lower than the core, to further effect a removal of stress away from the core.

27. (original) A method for protecting, and balancing stress in, a planar lightwave circuit having at least one optical waveguide core, comprising:

using at least one feature proximate the core embodying at least one stress-engineered property to balance stress and therefore minimize birefringence affecting the core; and

using a protective passivation layer over the core and the feature, the passivation layer formed to be substantially non-interfering with the balanced stress affecting the core provided by the feature.

28. (original) The method of claim 27, wherein said using the feature includes:

using an overcladding layer over the core, doped to balance stress affecting the core.

29. (original) The method of claim 28, wherein the circuit includes a substrate and an undercladding formed over the substrate, over which the core is formed; and

wherein the overcladding is doped to have a coefficient of thermal expansion approximately matched to that of the substrate to thereby symmetrically distribute stress in the undercladding between the overcladding and the substrate, and therefore away from the core.

30. (original) The method of claim 29, wherein the passivation layer has a coefficient of thermal expansion approximately matched to that of the overcladding such that it is substantially non-interfering with the balanced stress affecting the core provided by the overcladding.

31. (original) The method of claim 30, wherein the passivation layer comprises silicon nitride.

32. (original) The method of claim 30, wherein said using the feature includes:

using portions of the undercladding, respectively adjacent to each lower edge of the core, which terminate at a point lower than the core, to further effect a removal of the stress away from the core.

33. (original) The method of claim 30, wherein said using the feature includes:

using a stress release groove formed through the overcladding between two cores of the at least one core, the stress release groove releasing and therefore balancing stress affecting the two cores.

34. (currently amended) ~~The~~ A method ~~of claim 33, further comprising:~~ for protecting, and balancing stress in, a planar lightwave circuit having at least one optical waveguide core, the circuit including a substrate and an undercladding formed over the substrate, over which the core is formed; wherein an overcladding is doped to have a coefficient of thermal expansion approximately matched to that of the substrate to thereby symmetrically distribute stress in the undercladding between the overcladding and the substrate, and therefore away from the core, the method comprising:

using at least one feature proximate the core embodying at least one stress-engineered property to balance stress and therefore minimize birefringence affecting the core, wherein the feature includes using the overcladding layer over the core, doped to balance stress affecting the core; and

using a protective passivation layer over the core and the feature, the passivation layer formed to be substantially non-interfering with the balanced stress affecting the core

provided by the feature, wherein the passivation layer is comprised of silicon nitride has a coefficient of thermal expansion approximately matched to that of the overcladding such that it is substantially non-interfering with the balanced stress affecting the core provided by the overcladding, and wherein said using the feature includes: using portions of the undercladding, respectively adjacent to each lower edge of the core, which terminate at a point lower than the core, to further effect a removal of the stress away from the core and wherein said using the feature includes: using a stress release groove formed through the overcladding between two cores of the at least one core, the stress release groove releasing and therefore balancing stress affecting the two cores; and,
using a second overcladding along walls and floor of the stress release groove partially but not completely filling the groove to preserve its stress releasing property, but sufficient to support a generally planar portion of the passivation layer over the groove.

35. (original) The method of claim 33, wherein said using the feature includes:

using portions of the undercladding, respectively adjacent to opposing lower edges of each core, which terminate at a point lower than the cores, to further effect a removal of stress away from the cores.

36. (original) The method of claim 35, wherein the lower point corresponds with the desired bottom of the stress release groove, to thereby serve as an identifiable etch transition point for the stress release groove.

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37. (original) The method of claim 27, wherein said using the feature includes:

using a stress release groove through overcladding between two cores of the at least one core, the stress release groove releasing and therefore balancing stress affecting the two cores.

38. (currently amended) ~~The~~ A method ~~of claim 37, further comprising:~~ for protecting, and balancing stress in, a planar lightwave circuit having at least one optical waveguide core, comprising:

using at least one feature proximate the core embodying at least one stress-engineered property to balance stress and therefore minimize birefringence affecting the core, wherein said using the feature includes:

using a stress release groove through overcladding between two cores of the at least one core, the stress release groove releasing and therefore balancing stress affecting the two cores;

using a protective passivation layer over the core and the feature, the passivation layer formed to be substantially non-interfering with the balanced stress affecting the core provided by the feature; and,

using a second overcladding along walls and floor of the stress release groove to partially but not completely fill the groove to preserve its stress releasing property, but sufficient to support a generally planar portion of the passivation layer over the groove.

39. (original) The method of claim 27, wherein said using the feature includes:

using portions of an undercladding, respectively adjacent to each lower edge of the core, terminating at a point lower than the core, to further effect a removal of the stress away from the core.

40. (previously cancelled)

41. (original) A method for forming a stress release groove in a planar lightwave circuit, comprising:

providing a substrate and a waveguide undercladding formed thereover;

forming a waveguide core material layer over the undercladding;

etching portions of the waveguide core material away to form at least two waveguide cores, said etching proceeding into the undercladding between the two cores, to a point lower than the lower surfaces of the cores;

filling the etched portions with a waveguide overcladding; and

etching the stress release groove through the overcladding between the cores, and to the lower point, including sensing the lower point as an etch transition point.

Claims 42 to 43 (previously cancelled)

44. (original) A method for forming a planar lightwave circuit, comprising:

providing a substrate and a waveguide undercladding formed thereover;

forming a waveguide core material layer over the undercladding;

etching portions of the waveguide core material away to form at least two waveguide cores, said etching proceeding into the undercladding between the two cores, to a point lower than the lower surfaces of the cores;

filling the etched portions with a waveguide overcladding;

wherein the lower point of the undercladding between the cores relieves stress and resulting birefringence from the cores.

45. (original) The method of claim 44, wherein the distance between the point and the lower surfaces of the cores is proportional to the amount of stress relieved from the cores.